

REMARKS/ARGUMENTS

Favorable reconsideration of the present application is respectfully requested.

Claims 1 and 4 have been amended herein, and new Claims 7-16 have been added. Claims 2, 3, 5, and 6 have been canceled.

Claim 2 was rejected under 35 USC §102(b) as being anticipated by Chikuma (EP 066 210 A2). Without acceding to the rejection, and in an effort to focus attention on the patentability of Claims 1 and 4, and the new claims presented, Claim 2 has been canceled, as has Claim 3, which previously depended from Claim 2. The rejection under 35 USC §102(b) is thus rendered moot.

Claims 1 and 3-6 were rejected under 35 USC §103(a) as being obvious in view of Chikuma, Takaoka (U.S. 5,819,871), and a newly-cited patent to Downs et al. (U.S. 6, 286,474). Without acceding to the rejection, Claims 3, 5 and 6 have been canceled herein, Claims 1 and 4 have been amended, and new Claims 7-16 have been presented.

The Office Action stated that the Chikuma reference discloses an electrical power assisting steering apparatus having a worm wheel whose gear portion is made of synthetic resin and a core metal portion. The Office

Action further acknowledged that Chikuma does not disclose:

- 1) the use of a torque limiter mounted between the worm wheel and an output shaft, with the torque limiter having a ring member for applying elastic force;
- 2) the use of an output shaft made of an iron material and the use of aluminum or copper as the core metal material for the worm wheel;
- 3) a change in spacing between the worm wheel and the output shaft as a result of the differential thermal expansion between the materials which change operates to change a limit torque of the torque limiter from a lower value at a high temperature to a higher value at a low temperature.

The Takaoka reference is cited in the Office Action as disclosing the use of a torque limiter in the form of a ring member in an electrical power assist steering system. The Downs patent has been cited as allegedly disclosing a change in spacing between a worm wheel (34) and an output shaft (24) as a result of differential thermal expansion, and that this operates to change a limit torque of a torque limiter from a lower value at

high temperature to a higher value at a low temperature. The rejection cites to Column 3, lines 19-32 as disclosing the output shaft (24) being made of iron metal, and a core metal (36) being made of aluminum or copper alloy. Notably, shaft (24) is not even the shaft on which gear (36) is fixed or mounted.

The rejection of the claims asserts that it would have been obvious to modify the Chikuma device to include a ring-shaped torque limiter, and to provide a gear made of aluminum and shaft made of iron. The alleged motivation for the latter modification is that gear rattling would be reduced, allowing for smoother operation.

Amended Claims 1 and 4, and new Claim 7, all recite that the worm wheel has a core metal portion made of an aluminum material, and that the output shaft is made of an iron material. These claims also recite that the torque member is to be a ring member or metal member formed with a plurality of radially outwardly curved projections, and mounted between the worm wheel and the output shaft. The apparatus further has a construction such that the limit torque of the torque limiter will change or vary with temperature due to a change in spacing between the worm wheel and the output shaft

brought about by the difference in thermal expansion coefficients. The cited prior art, whether taken alone or in combination, fails to disclose or render obvious the invention set forth in Claims 1, 4 and 7.

The disclosures in Chikuma and Takaoka, even if properly combinable, disclose nothing more than an EPS apparatus having a worm wheel and output shaft made of iron material, and having a ring member used as a torque limiter provided between the output shaft and the worm wheel. The specification points out several disadvantages and problems experienced with such a construction. The invention as set forth in Claims 1, 4 and 7 herein recites a construction that overcomes or reduces the disadvantages and problems noted by the inventors relative to such an EPS apparatus. The cited prior art, and particularly the newly-cited Downs patent, does not address these disadvantages and problems in any way, and thus the invention cannot legitimately be said to be obvious in view of these references.

As noted in the present specification, among the problems present in the prior art constructions, including those employing torque limiters, is that, because the worm wheel and the output shaft are made of the same iron based material, the linear expansion

coefficients are approximately the same, so the limit torque of the torque limiter is essentially constant and independent of the temperature. Further, because the resin gear portion experiences a lowering of strength at high temperatures, the limit torque must thus be set at the maximum operating temperature of the apparatus, in order to avoid failure of the resin portion at elevated temperatures. The limit torque must also be set to a low value, taking into account the diminished strength of the resin gear portion at the elevated temperature. Over time, and with wear, this low level of the limit torque may decrease further, resulting in possible failure of the device to provide torque transmission. Additional problems with prior designs are discussed in detail at pages 1-8 of the present specification.

The invention recited in Claims 1, 4 and 7 addresses and overcomes, or reduces the effects of, these problems.

By providing a worm wheel made of an aluminum material, weight and inertia problems associated with the use of a large diameter worm wheel are reduced. The further provision of an output shaft made of an iron-based material, thereby setting up a differential thermal expansion in the construction, allows the limit torque to be set to a low value for operation of the apparatus at

high temperatures, and the differential thermal expansion will cause the limit torque to be higher at lower temperatures.

The citation of the Downs patent is misplaced. The Downs patent is not directed to an electrical power assist steering apparatus, it is directed to an engine balancer, which is an entirely different device. Persons of ordinary skill in the art directed to electrical power assist steering systems would not look to developments in engine balancers for possible modifications to power steering assist designs.

Contrary to the assertion made in the Office Action, the Downs patent does not address changes that may occur between an output shaft and a worm wheel, between which a ring member is disposed as a torque limiter. Instead, in the portion of Downs relied upon in the Office Action, Downs discloses using gray cast iron for two gears 34, 38, due to the noise-damping properties of gray cast iron. Downs further discloses the use of aluminum for gear 36 so that a degree of thermal expansion compensation relative to the balancer housing 27 and the engine cylinder block 12, can be obtained when those components are made of aluminum. Downs specifically states that gear 36 should be made from gray cast iron,

and not aluminum, if the balancer housing 27 and cylinder block 18 are made from gray cast iron. In any event, the aluminum gear 36 in Downs is not provided for the purpose of establishing a particular thermal expansion coefficient relationship with the shaft 22 that it is mounted on.

The discussion in Downs of making one of the gears of an engine balancer out of an aluminum material is addressing a problem wholly unrelated to the problems addressed by the present invention. The Downs apparatus does not involve a system in which a torque limiter is positioned between a worm wheel (or any other kind of gear) and an output shaft. Persons of ordinary skill in the art of designing electrical power assist steering devices would therefore find no motivation to apply the teachings of Downs to the design of such a power assist steering device.

Only in the present application is there any disclosure of providing a construction in which the limit torque of a torque limiter can be varied with variations in temperature. The construction set forth in Claims 1, 4, and 7 has the further advantages that aluminum is lighter in weight than iron and lower in inertia. The further recitation of the use of a torque limiter having

curved projections formed thereon, provides the further advantage that the outer diameter of the output shaft and the inner diameter of the core metal portion of the worm wheel need not be highly accurately machined. The desired limit torque can be obtained without such accurate machining.

Claims 1, 4 and 7, as now presented, are patentable over the cited Chikuma, Takaoka and Downs references. Withdrawal of the rejection of Claims 1 and 3-6 under 35 USC §103(a) in view of these references is thus warranted.

New dependent Claims 8, 11 and 14 depend, respectively, from independent Claims 1, 4 and 7. Each of these claims recites that the gear portion of the worm wheel, made of synthetic resin material, and the core portion of the worm wheel are joined by way of a chemical bond formed according to a composite molding technique. The Chikuma reference does not disclose or suggest the joining of these components in this manner. The cited portion of the Chikuma reference discloses only that the components are adhered together. Neither the Takaoka nor the Downs patent contains any disclosure that makes up for this shortcoming in the Chikuma patent. Claims 8, 11 and 14 are thus patentable over these references.



New dependent Claims 9, 10, 12, 13, 15 and 16 recite that the outer peripheral surface of the core metal portion of the worm wheel has irregularities formed thereon for strengthening the joining between the core metal portion and the resin gear portion. Again, none of the Chikuma, Takaoka or Downs references discloses such a feature. These claims are thus also patentable over the cited references.

All claims as currently presented are in condition for allowance. Passage of the application to issue at an early date is earnestly solicited.

The Commissioner is hereby authorized to charge to Deposit Account No. 50-1165 any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been requested separately, such extension is hereby requested.

Respectfully submitted,

Date: March 23, 2004

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